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WORKER ABSENTEEISM: AN ANALYSIS USING MICRODATA

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ABSTRACT

Worker Absenteeism: An Analysis Using Microdata*

This paper presents preliminary findings of a study of worker absenteeism. Our main purpose is to identify the various factors that influence the rate of absence for individual workers and to quantify their impact. Candidates for inclusion are measurable factors relating either to the structure of the terms and conditions of work (including the sick-pay scheme and disciplinary system); or personal characteristics of the workers themselves. The firm studied operates an experience-rated sick-pay scheme and the results reported in the paper concentrate on the analysis of a data set constructed from their payroll and attendance records. Under the scheme, workers' entitlement to sick pay in the current calendar year is determined by their record of absence over the previous two years. This is achieved by assigning the workers to three groups: good attenders (A), average attenders (B) and poor attenders (C). A worker's group is determined by the number of absence 'points' accumulated during the previous two years. Points are given for any absence that is not deemed acceptable. (Acceptable absences are mostly medically certified.) We find that for the most part, the firm's sick-pay scheme works most effectively on the duration of absence, and not its incidence. The incidence of absence appears to be determined mostly by personal characteristics (especially sex and marital status). We interpret this to mean that workers do not consider their entitlement to sick pay when commencing an absence, but that they do consider it when deciding to return to work.

JEL classification: 212, 229, 824

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NON-TECHNICAL SUMMARY

This paper presents preliminary findings of a study of worker absenteeism, which has two main goals. Firstly, we seek to identify the various factors that influence the rate of absence for individual workers. Candidates for inclusion are measurable factors relating to either the structure of the terms and conditions of work (including the sick-pay scheme and disciplinary system); or personal characteristics of the workers themselves.

Our data are drawn from the payroll and personnel records of a manufacturing company, which employs about 5000 production workers in four separate factories. The terms and conditions of work are for the most part centralized. The centralized sick-pay scheme was redesigned about five years ago with the specific aim of improving its incentive properties, and reducing the firm's sick-pay bill. The evaluation of this scheme is one of the central issues in our study. Our data stretches over 18 months from July 1987 and we are currently updating the database to include records for 30 months.

Our second main purpose is to measure the size of the effects on absenteeism of the factors we identify as important. This will assist the firm concerned in computing the costs and benefits of amending its personnel policies in various ways. For instance, during its wage bargaining the firm may consider using the sick-pay rate as a bargaining counter. Without careful assessment of the possible effects of this on absence and turnover, it is difficult for the firm to know the trade-offs involved in using this as a bargaining tool.

In order to analyse this problem, we adapt methods commonly employed in the analysis of labour supply. These methods are designed to handle a wide variety of institutional arrangements and are thus well suited to the exercise carried out here.

The firm studied operates an experience-rated sick-pay scheme and the results reported in the paper concentrate on the analysis of this scheme. Workers' entitlement to sick pay in the current calendar year is determined by their record of absence over the previous two years. This is achieved by assigning the workers to three groups: good attenders (A), average attenders (B) and poor attenders (C). A worker's group is determined by the number of absence 'points' accumulated during the previous two years. Points are given for any absence that is not deemed acceptable: acceptable absences are mostly medically certified. In the event that they are absent, Group A workers receive sick pay equal to basic wages plus normal bonuses (to a maximum of 1/3 basic), Group B workers receive basic pay only, while Group C workers receive only statutory sick pay. Given the rich structure of the scheme, there are many parameters that could be altered. Our analysis explores the effect on absence rates of changes in the parameters of the scheme. An example is given below.

This kind of scheme creates a complex problem for the worker, because in deciding whether or not to attend work, he or she has to take into account not only the immediate financial consequences, but also the implication of the absence on points and the constraint that will face them in the future.

The empirical part of the paper divides the problem into two parts. We analyse incidence of absence using a sequential logit specification, and duration using a Weibull hazard model (with corrections for over-dispersion due to unobserved heterogeneity).

Any brief summary of our findings is sure to involve an element of caricature, but we find that for the most part, the structure of firm's sick-pay scheme works has the greatest impact on the duration of absence and not on its incidence. The incidence of absence appears to be determined mostly by personal characteristics (especially sex and marital status). We interpret this to mean that workers do not consider their entitlement to sick pay when commencing an absence, but that they do consider it when deciding to return to work.

It is probably premature to place too much stress on the size of the effects that we have identified, but to give an idea of the sort of estimates that can be produced, we include the following examples:

- Our estimates indicate that reducing by two the number of points required to take a worker from the A/B boundary to the B/C boundary would reduce absence by about 3%. (That is, a factory that had a rate of 5% would be able to reduce it to 4.85% by this means).

- A policy designed specifically to reduce absence on a Monday is unlikely to have a very big effect at all.

- We are currently working on improved estimation techniques for these problems. In particular, the theoretical structure suggests the use of structural modelling as suggested in a 1987 paper by Rust, and we are adapting his techniques to our particular application.

Studies of absenteeism by economists are few and far between, despite the fact that we have a well understood model of time allocation and labour supply, and that data on absenteeism are not difficult to come by. What literature there is has failed to identify robust and well-determined estimates of the effects of variables that economists would want to associate with a labour supply phenomenon of this sort. On the other hand there is a large and flourishing literature in the applied psychology literature. These papers are generally empirical in nature but progress in this literature has been severely hampered by the lack of an commonly accepted theoretical structure.

This paper follows up a remark of Barmby and Treble[1989], that the dearth of convincing empirical evidence in the labour economics literature may be due to an identification problem. That is, existing empirical exercises have largely ignored the possible influence of demand side factors on absence. In this paper, we make an initial attempt at rectifying this by using microdata in which the system of absence control is well defined. The work reported here should be regarded as a necessary preliminary to more sophisticated modelling of the demand side of the market, since it only includes demand side factors that are embodied in the structure of the sickpay scheme. The data are drawn from the personnel and payroll records of a firm which operates a sophisticated sickpay scheme as one of its two main methods of absence control. The other method is the use of a system of cumulative warnings. While we have gathered data on warnings, we have not yet integrated this aspect of the control system into our analysis.

The results obtained demonstrate the potential importance of including financial aspects in the explanation of absence behaviour, although the inclusion of financial variables does not cause us to reject the importance of individual (household) characteristics or characteristics of the work contract and job environment.

The paper is organised into three main sections. The first is a brief review of the literature on absence. The second gives details of the data and the industrial background against which it was generated. The third presents our results.

SECTION I. The literature on absence: a selective review

The task of conveying to the reader the main results of the literature on industrial absenteeism is made difficult by the fact that at least three separate literatures exist, none of which is entirely satisfactory. These three literatures derive from the work of applied psychologists, management specialists and economists. In this review, we will not consider the management literature, since it is concerned with practice rather than the systematic investigation of the determinants of absence behaviour. It rests for the most part on the results obtained by industrial psychologists, mixed with folk wisdom and a generous seasoning of experience in the field.

Despite the concentration on the work of economists and psychologists, any review of what is known about absence must start with some careful early work by two specialists in industrial health. This work is distinguished by the use of microdata referring to a large number of British coalminers, and by its careful use of the available statistical technique. In a pair of neglected studies (Vernon and Bedford[1928], and Vernon, Bedford and Warner[1931]) the authors used data from ten collieries, located close to each other in the Nottinghamshire coalfield. The coal seams on which the miners worked varied greatly in depth, and in the physical conditions of work (thickness of seam, temperature, humidity and airflow). Using simple regression analysis applied to grouped data, Vernon and Bedford investigate the relationship between these variables and three different classes of absence: sickness absence, absence due to accidents, and a residual class labelled 'voluntary'. They find that total absenteeism increases with the depth of the workings for all classes of worker, and that absence from sickness increases greatly with underground temperature. Since there is a correlation of .95 between the two independent variables these facts are difficult to interpret. Absenteeism from sickness is also associated with air velocity. This is attributed to the liability of lightly clad men to catch chills.

Accident frequency was found to increase with underground temperature, but this effect was confined to minor accidents, so that accident severity is not overall responsive to temperature. This difference in the patterns of major and minor accidents prompted further investigation of the relationship between accidents and underground temperature. Vernon, Bedford and Warner[1931] conclude that the reason for minor and not major accidents being correlated with conditions undeground is to do with incentives in the sickpay scheme: a worker was more likely to report a minor accident in order to claim 'compensation' if his workplace was unpleasant, than if it were pleasant. From an economist's point of view, this finding, tentative though it might be, is a very interesting one, but it has not been followed up carefully in subsequent literature.

Despite Vernon and Bedford's work, interest in absenteeism as a phenomenon worthy of academic study has been largely confined to the last two decades. Most of the literature has been devoted to empirical (with some experimental) studies of the problem as a psychological phenomenon, with the occasional contribution by economists. The psychological literature has been reviewed by Steers and Rhodes[1978] and by Fichman[1984]. These two papers are also of significance, because they contain attempts to cater for the lack of an accepted psychological theory of absence behaviour.

Steers and Rhodes' model is not specified in detail, but it does incorporate some important features. Notably, the personal characteristics of individual workers are stressed as determinants of the ability to attend. They also interact with job characteristics to determine satisfaction with the job situation, which in turn (moderated by exogenous pressures to attend) determines attendance motivation. Ability and motivation to attend determine observed employee attendance in the model. Steers and Rhodes also stress the importance of feedbacks from observed attendance to the job situation (e.g. attendance record may be a factor in promotion), and pressure to attend.

The question that an economist would routinely ask about a theory is: Is it capable of falsification? In the case of the Steers/Rhodes model the answer must be no. Many of the variables used as primitive concepts in the structure are poorly defined, and incapable of measurement: 'Role stress', 'work group norms', and 'personal work ethic', are all examples. In addition, the direction of many influences is not specified; for example, do pressure to attend and 'family responsibilities' increase or decrease attendance?

Thirdly, Steers and Rhodes themselves have some harsh things to say about the quality of the empirical work on which their results are based. At the time they were writing, studies had been largely based on the examination of simple bivariate correlations. There are problems of comparability (partly caused by poor reporting practices), and a failure in experimental work to design experiments carefully. They also raise the question of efficiency: "... some absenteeism may in fact be 'healthy' for organizations in that such behavior can allow for temporary escape from stressful situations ... (R)igid efforts to ensure perfect attendance may lead to unintended and detrimental consequences on the job ..."

The Steers/Rhodes view of the world remains an important contribution to the literature on absenteeism despite the fact that it was built on admittedly shaky foundations and has not been found very convincing. In his later review, Fichman[1984] concludes that the "Steers and Rhodes model both has theoretical problems and lacks strong empirical support." He continues his review with an attempt to summarise the issues that a theory of absenteeism would be required to handle, and concludes with some suggestions for a theoretical framework that would do the job. Fichman's suggested theory is, once again, not very clearly specified although what he has in mind is a model that treats absenteeism as a model of the allocation of time, and that is dynamic: a sort of model of the allocation of time over time.

Since publishing his review, Fichman[1988],[1989] has begun to put into operation part of the program suggested by his paper. He treats absence and attendance as dynamic phenomena. Over time an individual switches from one state to the other and the analyst's task is to model the determinants of these switches. The statistical methodology uses a Weibull hazard function to model the probability of a transition from attendance to absence, while Harrison and Hulin[1989] use the closely related Cox model (Cox[1972]). Harrison and Hulin include no quantitative measures of financial variables. Fichman[1988], however, finds significant differences in the hazard function for the start of an absence that is unpaid, compared to the start of one that is paid.

The perennial weakness of the psychological literature is its inability to provide a coherent theoretical model. By contrast, in economics, a model for the absence decision based on the income-leisure model is unlikely to be controversial. As far as we know, the only piece of empirical work by an economist based on individual data and informed by such a model is Allen[1981], which reports robust effects of safety, health (the values of these coefficients are rather puzzling), and age. A wage effect is significant only in an equation excluding personal and industrial characteristics. When these are included the effect disappears. Furthermore, when Allen breaks his data down to white-collar and blue collar subgroups, the wage effect is present only when it is accompanied by a dummy variable (itself insignificant) describing whether sickpay is payable or not, and only in the blue-collar subgroup. For this subgroup, the robust reported effects are those of union membership and sex, although Allen's paper does not report all the estimates for this breakdown. The white-collar results display a significant effect for other household income only.

In a recent note, two of the present authors (Barmby and Treble[1989]) suggested that a possible reason for the difficulty experienced in interpreting results such as these, was neglect of the identification problem. The usual response of a personnel manager to an observed increase in absence is to launch a campaign of some sort, maybe by changing the rules, or enforcing them more rigorously. Indeed, the common theme of the management literature is that absenteeism is controllable by management. With demand side effects present, it may be difficult to disentangle their impact on observed absence from the impact of supply side effects. Our motivation for undertaking the work reported here was to attempt to resolve the identification issue by careful modelling of the absence control system used by the firm studied. This system has two parts: a sophisticated experience rated sickpay scheme, and a system of cumulative warnings leading to ultimate dismissal. Since this is a report on work in progress, and we have not yet incorporated information on warnings into our database, we are only able to present here results based on analysis of the sickpay scheme. This scheme, and other features of our data, are described in the next section.

SECTION II. The data

The firm from which our data are drawn introduced its experience rated sickpay scheme in 1983 following management concern that the costs of its previous sickpay scheme were higher than actual levels of sickness might suggest. That is, managers believed the previous sickpay scheme not to be incentive compatible. The new scheme provides sickpay at three different rates, over and above the statutory sickpay (SSP) rate: Grade A workers are paid their full normal earnings including bonuses (although the latter are limited to 1/3 of basic pay) less SSP; Grade B workers are paid basic pay less SSP; Grade C workers receive no benefits from the company sickpay scheme. All workers remain eligible for SSP, in addition to their company sickpay entitlement

Workers are assigned to these three grades according to their absence record over the previous two years. Each day of absence is assigned a certain number of 'points', which are cumulated over the appropriate period. Workers are assigned Grades according to the following function:

$$\text{GRADE} = \begin{cases} A & \text{if points} \leq 21 \\ B & \text{if } 21 < \text{points} \leq 41 \\ C & \text{if points} > 41 \end{cases}$$

A day of absence can attract zero, one or two points depending on the kind of absence and whether SSP is payable or not. Any absence which is 'acceptable' attracts zero points. The criterion of acceptability is usually admission to hospital, or serious medically certified sickness. Self-certified sickness is rarely, if ever, acceptable. Days on which SSP is not payable attract double points. (These are usually the first three days of an absence spell, except when there has been a separate spell of absence within the previous eight weeks.) This provision was built in to the scheme because the cost to the company sickpay scheme of a day when no SSP is payable is greater than the cost of an SSP day. Finally, workers who have no absence in a year are awarded a ten point bonus.

We are therefore confronted with a system in which a worker's decision to be absent has two consequences. Firstly, for many workers there is an immediate loss of earnings[1]; secondly, their eligibility for sickpay at some future date is affected, usually in a stochastic fashion. The incentives created by the scheme are therefore highly complex, and provide many opportunities for econometric analysis.

Our database consists of the whole payroll of the firm's four factories for 18 months from September 1987 to March 1988, with the addition of data drawn from these factories' absence records. This records daily absences and annual sickpay grades, and the daily accumulation of non-acceptable absence points counting towards the determination of the sickpay grade. The data from the absence records are available for four years, calendar 1985 to 1988, although there is a fair amount of missing information, particularly in the earlier years[2].

The overall rate of absence can be broken down into two factors. Incidence, or the number of absences taken by workers during the year; and duration, the length of time for which workers are off. We deal with duration patterns below. Our data, summarised in Table I, show a considerable variation in incidence over factories, sex, marital status, shifts and types of workers. These patterns also appear to be quite durable over the four year period for which we have data. Firstly, Factory 4 is consistently the leader in the incidence league table, although the margin of its dominance has tended to decline over the study period. This is partly because of a fall in incidence in Factory 4, and partly because of a increase in incidence in the other factories.

Turning to the breakdowns, there is remarkable consistency in incidence patterns that extends across all four factories. Single workers have higher incidence of absence than married workers and female workers have a higher incidence of absence than males. It seems quite surprising that a phenomenon as complex as absence should show such consistency over time and factories.

Absence durations also show some interesting patterns. The main source of our comments is a set of Appendix tables (available on request from the authors), where we tabulate absence by duration for durations of five days or less and the day of the week on which each absence started. Some summary statistics are reported in Table II. We have concentrated on these short durations mainly in order to keep the tables to a manageable length, but it is worthwhile picking these short durations out for special attention for two reasons: firstly, they account for the majority of absences (although not of days lost). Table III documents this.

Secondly, it is almost certainly the case that improved methods of absence control are best targeted at these short absences, since the longer absences are better documented as having medical or other permissible justification, and workers have greater discretion over shorter absences. It is perhaps worth reiterating that our later analyses will not limit our sample in this way, and that the figures reported in Table II refer to *all* absences, not just the short ones.

Factory 4 emerges with the highest durations, followed by Factory 1, Factory 3 and Factory 2. There is therefore no simple correlation of incidence and duration, except that Factory 4 turns out worst on both counts. Neither do there appear to be any simple patterns emerging from the breakdowns by sex and marital status, shifts or worker type. There is, however considerable variation in durations that we hope to be able to explain in our statistical analyses.

The one pattern that does emerge from these simple crosstabulations is to do with the day of the week. With one exception, in each factory and for each class of worker the longest mean durations begin on a Tuesday. (The exception is the single males in Factory 3.) The Appendix tables show clearly that a partial explanation of this is that the matrices of duration have a very prominent diagonal (from top right to bottom left) and that the entries above the diagonal tend to be larger than those below. Table IV is an extract from the Appendix tables illustrating this.

The prominent diagonal in Table IV means that many absences end on a Friday. That is, no matter what day of the week an absence starts on, it is more likely to end on a Friday than on any other day. This is true for nearly all absences other than those starting on a Monday, which often also finish on a Monday. Thus for many of the tabulations, we have most four day absences starting on a Tuesday, most three day absences starting on a Wednesday, most two day absences staring on a Thursday, and single day absences generally split between Monday and Friday. Thus mean durations are low for absences starting on a Monday because many of these are one day absences, rise on Tuesday and tend to decline during the rest of the week.

We have to be a little careful in interpreting these duration figures, because they are heavily censored. The well known phenomenon of a lot of short absences starting on a Monday, is at least partially due to the fact that illness doesn't care whether it strikes during the week or during the weekend. In a perfectly regular world, we would expect to observe three times as many absences starting on a Monday than on any other day of the week, and an excess of absences ending on a Friday. In our formal analysis of the duration data we take account of this censoring by the use of an appropriate likelihood function.

Finally, we consider some statistics on days lost. An interesting feature of the days lost figures is that they do not show the widely perceived predominance of Monday as a high absence day. (See text table above, for instance.) In fact, most of the distributions show Mondays to be relatively *good* days as far as loss due to absence is concerned. How can we explain this? Recorded absences on Mondays are biased downwards by the fact that most public holidays in Britain occur on a Monday. Adjusting the Monday figure in Table IV, by the appropriate factor (52/48), yields a figure for Monday (4913) roughly comparable with the figures for the other days of the week, and lends some further support to the censoring argument given above.

The days lost per worker provide a summary measure of the seriousness of the absence problem, in each factory and within each subgroup of the workforce. The most striking thing about them is that they do not pick out

Factory 4 as being much worse than the other factories. The usual measure of absence (proportion of shifts lost) puts absenteeism in Factory 4 at two or three times the Factory 3 level. These figures therefore look a little suspicious. There are several reasons why they may give a different result to the more conventional measure. The most important is probably that they only refer to workers who have stayed employed throughout the four year period. Thus measures of this kind will be sensitive to differential rates of turnover if workers who leave employment during the period have different absenteeism behaviour from those who stay. Another way of thinking of this bias is that our sample underrepresents employees who only stay for short employment durations. If absence rates are higher for this group, our measure will understate the true extent of absenteeism. This leads us to think that the study of absence would be enhanced by a concurrent study of turnover. We would also note that biases of this sort are not present in the work reported in the final section of the paper, which is based on statistics computed from the records of all workers.

SECTION III. The sickpay scheme and absence: some early results

In Barmby, Orme and Treble[1989], we give details of a dynamic model of worker decisions under the sickpay scheme described in Section II. We are not yet in a position to report on estimation of the full model and restrict our attention in the present paper to the relatively simple task of modelling the incidence and duration of absence treating the present year's grade as predetermined. Furthermore, we concentrate on the incentive properties of the threat of lower future sickpay grades, by looking at the effect on absence behaviour of proximity to the boundary. Our model, which treats sickness as a random occurrence, generates some simple predictions of these effects. The intuition of the argumant is as follows: Consider two individuals who are identical except that one has in the past had more frequent sickness than the other. At a given date, these two individuals will thus have different points accumulations simply because of differing degrees of bad luck. In deciding on their current absence behaviour they are thus confronted with lotteries that have the same payoffs (the utility equivalents of staying in their current sickpay band or not), but the worker with the higher points total will have a higher probablility of receiving the low payoff, by virtue of the random incidence of sickness. He thus has a greater incentive (given identical tastes and sick-proneness) to avoid absence.

In this section we look for effects of this kind in the data. This Section contains some preliminary results of our empirical work. We have adopted two modes of analysis: The first uses a sequential logit analysis to investigate the incidence of absence; the second estimates the parameters of a Weibull hazard model of duration, taking account of the weekend censoring described above. Both models take into account the fact that individual will differ in respect of personal characteristics and job and contract characteristics.

In our incidence work we count one incidence of absence if an individual goes absent for a defined reason within a specified time period. The time period adopted is one week and therefore an absence is counted if the individual was absent for the week or any part or parts of the week. An individual's distance both in terms of points and time to the next sick pay boundary will be important components of the specification. We also take account of the fact that a single absence spell may be recorded over more than one week and therefore it is difficult to maintain as a hypothesis the independence of successive weekly absences. The probability of being absent in a given week might exhibit a dependence on past observed absence. This is captured by entering lagged absence as an explanatory variable. We define

$$d_{ik} = \begin{cases} 1 & \text{if individual } i \text{ is absent in week } k \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

and employ a logit formulation to model probabilities

$$P_{ik} = \text{Prob}(d_{ik}=1) = [1 + \exp(-x_i\beta - z_{ik}\gamma - d_{ik-1}\lambda)]^{-1} \quad (2)$$

We can now write down an expression for the joint probability of a given event sequence, as

$$\prod_{k=1}^{K} P_{ik}^{d_{ik}} \; (1-P_{ik})^{1-d_{ik}} \quad (3)$$

and the product of these terms over sample individuals yields the likelihood function for parameters β, γ and λ, where the use of the lag terms defines a restricted covariance structure.

The modelling of the effects of the sick pay scheme are attempted in two ways, firstly by a series of specially defined constants defining where the individual is in the sick pay scheme. CONST1 indicates that the individual is a perfect attender to date, CONST2 refers to an individual with some absence but is still within the A grade, that is his or her points from the present year to date plus the points cumulated from the previous year are no greater than 21. The appropriate boundary for this individual is the A/B one. CONST3 is the constant specific to a B graded individual and CONST4 for C. The second way in which the sick pay scheme can condition present behaviour is through the distance to the appropriate boundary in terms of points yet to "travel". However simply entering points on their own is unlikely to capture effectively any disincentive effects simply because there still will be considerable heterogeneity over individuals in terms of calendar time to the same boundary. We attempt to capture this effect by using points per remaining time periods as the appropriate distance measure. As can be seen from the following results there will be two relevant distances D1/T as "distance" to the A/B boundary and D2/T as "distance" to the B/C boundary, these being entered both linearly and quadratically into the specification to allow for some flexibility in the path of probabilities into the boundary.

Details of the results obtained are given in Barmby, Orme and Treble[1989] (Table 5). Here we point out their main features. The statistically significant factors determining the likelihood of an incidence of absence are sex and marital status. Table V reports the *elasticities* of the likelihood with respect to the given variable.
To illustrate the meaning of these figures, suppose that absence at Factory 3 were running at 6%, and there were a 10% increase in the number of married women employed. The predicted change in the absence rate would be approximately $(7/9\times(-0.29) + 7/9\times(-0.49) + 0.14) \times 10\% \times 6\% = -.28$, where 7/9 is roughly the proportion of all women in the labour force who are married, and is also roughly the proportion of all married people in the labour force who are women. This change would thus cause a fall in the absence rate to 5.72%. The other major influence on absence rates revealed by the analysis is contract hours. This is a very well determined effect, but we do not feel able to commit ourselves to a view on the likely effects of changing contract hours without some further research, especially

investigating the effect of wages, which are not included in the present specification.

Turning now to the effects of the sickpay scheme, it appears that as far as incidence is concerned, the effect of the boundaries on incidence are relatively weak, except at Factory 4. We also pick up a significant incidence effect close to the B/C boundary in the Factory 3 data.

We now consider the specification of a duration model for observed absences. The specification is not as straightforward as it might be due to the way in which absence histories have been recorded. This essentially creates grouped, or censored, duration data of a type not often encountered in text book expositions (i.e., Cox and Oakes (1984), Kalbfleisch and Prentice (1980), who only consider at any great length the right censored case). However, the analysis of grouped data (duration or otherwise) has received attention in the journal literature (see, for example, Burridge (1981), Chesher and Irish (1987) and Turnbull (1976)) where appropriate adjustments to standard techniques have been discussed.

For the duration analysis we have used a flow sample of individuals over an eleven week period. All absences within this eleven week window have a known recorded start and end date and the problem of censoring would appear not to arise. However, as we observed in section II, the start and end days of a spell of absence for a particular individual are only recorded on Monday-Friday (inclusive), for a five-day working week (Monday-Thursday, for a four-day working week). This implies that no start or end days for a spell of absence are ever recorded as Saturday or Sunday (Friday, Saturday or Sunday for a four-day working week). Furthermore, for simplicity, durations of absence which are recorded as spanning more than one working week are assumed to be single spells incorporating the intervening weekends. Thus if we wish to allow for an absence to be caused by illness, we must also allow for any recorded durations to be censored accordingly.

Our specification uses a Weibull hazard model which can be readily estimated by maximum likelihood techniques. We also adopt a correction procedure designed to correct the MLE's for local specification error, in particular neglected heterogeneity of unknown form, in the survivor function[3]. Models for the duration of events are most commonly specified in terms of the hazard function, which itself is just a convenient transformation of the density function of the random duration, T. Such models are now common in the literature. A concise exposition can be found in Lancaster[1990]. Here we describe the case where the observed durations are censored in the manner described above. The exposition given below is for a general censoring mechanism, in the sense that the algebra allows for both right- and left-censoring.

Consider the case where realisations of T are not fully observed due to censoring. Assume that the duration is either (i) fully observed, or (ii) it is censored in that, if the observed duration is z, the actual duration is known only to lie in the range $z<T<z+t(h)$, for some known constants $t(h)$, $h=1,\dots,m$. That is to say, censored observations fall into one of m classes (or groups), characterised by $z<T<z+t(h)$, $h=1,\dots,m$. For completeness, class 0 is the case when the duration is fully observed, so that for all cases the random duration being modelled is $Y = \min(T,z)$, where z is some censoring point. For the recorded absence data we have the spell is either complete, "left censored", "middle censored" or "right censored". Accordingly $m=2$ with $t(0)=0$, $t(1)=2$, $t(2)=4$ ($t(1)=3$, $t(2)=6$, for a four-day working week). Notice that observations, z, which are "left" or "right" censored (but not both) make algebraically identical contributions.

Proceeding generally, we define the following indicators for an observed duration, y , on individual i,

$$D_h = \begin{cases} 1, & \text{if y falls into group h, h=0,...,m} \\ 0, & \text{otherwise,} \end{cases}$$

where $\sum_{h=0}^{m} D_h = 1$.

The probability that the observed duration falls into group h (h>0) is given by

$\text{Prob}\{z_i < T_i < z_i + t(h)\} = S_i(z_i) - S_i(z_i + t(h)) = P_i[z_i;t(h)]$, say, where $S_i(z_i)$ is the Weibull survivor function.

Consequently, the log-likelihood based on n independent observed durations, $y_1,\ldots,y_n$, is

$$L(\theta) = \sum_{i=1}^{n}\{ D_{i0}\log(f_i(y_i)) + \sum_{h=1}^{m} D_{ih}\log(P_i[y_i:t(h)])\} \qquad (6),$$

where $\theta' = (\beta',\alpha)$, $y_i = D_{i0}t_i + \Sigma_h D_{ih}z_i$ and $f_i(y_i)$ is the Weibull density at the point y_i. Maximising L over θ gives the MLE's which shall be denoted $\tilde{\theta}$. The above specification of the censoring scheme allows for the following two specific cases:

(a) no censoring at all : m=0, in which case $D_{i0} = 1$ for all observations; and

(b) commonly encountered right-censored data : m=1 with $t(1)=\infty$ and $D_{i1} = 1-D_{i0}$.

For the Weibull model, where the hazard function is specified as $\lambda_i(t_i) = \alpha\exp(x_i'\beta)t_i^{\alpha-1}$, maximum likelihood estimation is a fairly straightforward procedure because the Weibull model is a member of a wider class of models which were shown by Burridge (1981) to have globally concave log-likelihoods, even when the data are censored in the above fashion. A Newton-Raphson iterative scheme exploiting analytic second derivatives can be used to locate the MLE's and to compute asymptotic standard errors.

The MLE's were corrected for local specification error (neglected heterogeneity of unknown form) and standard errors obtained using the method described by Orme (1989). Corrections were based on the information matrix test (see White (1982)) where the only contributions to the indicator vector come from the intercept term in the regression $x'\beta$ (see Lancaster (1985), Kiefer (1985), Sharma (1987)). That is, the test indicator takes the following form

$$\frac{1}{n}\sum_{i=1}^{n}\left[\frac{\partial^2 l_i}{\partial\beta_0^2}+\left[\frac{\partial l_i}{\partial\beta_0}\right]^2\right]_{\theta=\tilde{\theta}} = \frac{1}{n}\sum_{i=1}^{n}\tilde{d}_i \qquad (8).$$

An asymptotically valid χ_1^2 test statistic can be calculated as the sample size, n, minus the residual sum of squares from an artificial regression where the left hand side variable is 1 for all observations and the right hand side variables consist of $\{\tilde{d}_i\}$ and the contribution to the score vector, namely $\{\partial\tilde{l}_i/d\beta'\}$ and $\{\partial\tilde{l}_i/d\alpha\}$. The necessary updates that are added to the MLE's to produce corrected estimates are the estimated coefficients on the contributions to the score vector from this regression; estimated standard errors can also be retrieved from this regression (see Orme (1989)), as follows. After running the above regression, let VOLS1 be the estimated OLS variance for the estimated coefficient on the j element of the score contributions (j=1,...,k+1) and s_1^2 the OLS residual variance; run a similar OLS regression but drop the right hand side variable $\{\tilde{d}_i\}$ to obtain $VOLS2_j$ and s_2^2. The estimated variance of the obtained corrections are then $VCOR_j = VMLE_j - VOLS2_j\,/(s_2^2) + VOLS1_j\,/(s_1^2)$, j=1,...,k+1,; where $VMLE_j$ is the estimated variance obtained from the initial maximum likelihood program.

Our results are summarised in Table 6, and are based on samples of absences at each factory between September and November 1988. They can be interpreted in a similar way to the incidence results. What we have modelled is the probability that a person will return to work once he or she has had an absence of a given length. The lower this probability, the longer the absence will tend to be, and vice versa.

Once again, sex and marital status emerge as important determinants of duration. Female workers and married workers tend to have longer absences than males and single workers respectively. The exception to this is Factory 3 where female seem to have shorter durations than males. We are not quite sure why this should be, but we would note that the results from Factory 3 differ from the other factories in other ways too. In particular, notice the way that the 1988 grade assignments have large t-ratios in Factory 3 where in the other factories they do not. We suspect that our planned effort at modelling the movements of workers between grades may shed some light on these rather odd results.

The remaining features of the results are not odd at all. As one would expect absences that are acceptable (do not attract points) tend to be longer than those which are not. Workers who have no SSP waiting days also tend to have longer absences, perhaps because these workers will usually be in worse general health than others, but perhaps also because the points cumulate more slowly in the first three days of an absence for these workers.

Some of the variables TUESDAY, WEDNESDAY, THURSDAY and FRIDAY are significantly different from zero, indicating that the start date is of importance, independently of the censoring problems described above. The estimates are measured relative to Monday, and probably the easiest way to interpret them is imagine a 1% reduction in absences starting on a Monday. This would have an impact equal to the sum of all the elasticities of the "day of the week" variables, and would thus reduce overall absence by about .07% in Factory 3, by about .26% in Factory 2, and by .31% in Factory 4. (Note that these are percentages not percentage points, so that these effects are tiny.)

Finally, as in the incidence analysis, we have incorporated a measure of distance to the next boundary. We did not divide by time to the end of the year since our sample is drawn from a relatively short period of time and this factor is probably irrelevant. The results make a sharp contrast with those on incidence, since it appears that the points cumulation is an important determinant of absence durations. Furthermore, the B/C boundary has a stronger effect on workers' behaviour than the A/B boundary, except in Factory 3 where the A/B boundary has a greater effect. In both cases, proximity to the boundary has the desired effect of reducing the duration of absence.

The results reported here on the boundary effects are not without their problems. Both Factory 2 and Factory 4 have negative signs on the A/B boundary variable and we would want to do some further investigation of this. If we take the measured B/C boundary effects seriously, then the addition of 2 points to each worker's total as they cross the A/B boundary would reduce absence by about 3% in all three factories. (Once again this is a percentage, so that a factory with a 10% absence rate would be down to 9.7%.)

SECTION IV. Conclusion

This paper reports some preliminary results of a study of a large new dataset drawn from the payroll and absence records of a British manufacturing firm. We believe that empirical studies of absence have suffered in the past from a failure to account for an identification problem. Vernon and Bedford's[1931] finding of a well-defined response of absence to the provisions of a sickpay scheme have not been replicated in later work. We suspect that this is in part due to the fact that absence control in the industry studied by these authors was not very tight, so that observed absence was driven by the supply side of the market. Our approach to solving the identification issue in our current data is to model carefully the rather complex constraint system facing the workers. The results in this paper are a first attempt at this, and are sufficiently encouraging to cause us to want to refine our methods in later work. In particular, we find well determined (although not easily interpretable) effects of the sickpay scheme on duration of absence. Sickpay provisions do not appear to to enter the explanation of incidence.

FOOTNOTES

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1. It should be clear from the above description that some workers will not suffer any immediate loss of earnings. These are Grade A workers whose bonuses are less than 1/3 of their earnings at basic rate, and Grade B workers who earn no bonuses.

2. Since the preparation of this paper, the database has been extended to cover a further 9 months to December 1989.

3. For a more detailed discussion of neglected heterogeneity see Chesher (1984), Lancaster (1985), Lancaster, Chesher and Irish (1985), Kiefer (1985), Sharma (1987). For a detailed discussion of correction procedures, including asymptotic distribution theory, see Orme (1989).

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TABLE I
MEAN INCIDENCE OF ABSENCE

ALL WORKERS	1985	1986	1987	1988
FACTORY 1	1.909	2.077	2.244	2.130 (621)
FACTORY 2	2.390	2.732	2.566	2.608 (586)
FACTORY 3	1.788	1.639	1.765	1.750 (660)
FACTORY 4	4.272	3.573	3.517	3.247 (750)
FACTORY 1				
MARRIED FEMALES	1.948	2.246	2.269	2.122 (297)
SINGLE FEMALES	2.625	2.736	3.123	3.056 (73)
MARRIED MALES	1.455	1.286	1.877	1.748 (214)
SINGLE MALES	1.633	2.167	2.405	2.568 (37)
FACTORY 2				
MARRIED FEMALES	2.488	2.759	2.526	2.495 (216)
SINGLE FEMALES	3.000	3.851	3.343	3.343 (67)
MARRIED MALES	2.138	2.464	2.308	2.522 (224)
SINGLE MALES	2.329	2.468	2.747	2.532 (79)
FACTORY 3				
MARRIED FEMALES	1.765	1.639	1.831	1.779 (310)
SINGLE FEMALES	2.250	2.198	2.417	2.427 (96)
MARRIED MALES	1.281	1.167	1.202	1.307 (114)
SINGLE MALES	2.000	1.644	1.544	1.505 (101)
FACTORY 4				
MARRIED FEMALES	4.375	3.625	3.568	3.471 (420)
SINGLE FEMALES	4.937	4.242	4.032	3.553 (95)
MARRIED MALES	2.921	2.561	2.453	2.288 (139)
SINGLE MALES	5.125	4.146	4.250	3.354 (96)

TABLE II
MEAN DURATION OF ABSENCE (STAYERS)

	M	T	W	T	F	ALL
FACTORY 1	5.22	7.24	3.90	4.25	3.40	5.12
MARRIED FEMALES	5.41	8.12	3.89	4.09	3.31	5.35
SINGLE FEMALES	5.43	7.38	4.84	4.03	3.84	5.41
MARRIED MALES	4.99	5.71	2.92	5.14	3.72	4.75
SINGLE MALES	3.88	4.34	4.14	3.47	2.26	3.74
FACTORY 2	4.50	5.02	3.25	3.54	3.39	4.22
MARRIED FEMALES	5.41	6.51	3.96	3.66	4.10	5.03
SINGLE FEMALES	3.82	4.33	2.99	3.59	3.46	3.71
MARRIED MALES	4.28	4.04	2.80	3.54	2.68	3.92
SINGLE MALES	3.85	3.68	2.36	2.96	2.00	3.36
FACTORY 3	5.28	5.49	4.92	4.42	3.48	4.84
MARRIED FEMALES	5.74	6.33	5.75	5.01	3.71	5.40
SINGLE FEMALES	3.95	4.41	4.19	3.75	2.80	3.95
MARRIED MALES	5.78	5.22	4.49	5.23	2.36	4.89
SINGLE MALES	4.35	4.33	3.26	2.26	4.51	6.10
FACTORY 4	6.06	8.34	4.49	3.91	4.30	6.10
MARRIED FEMALES	6.37	8.85	4.79	4.04	5.86	6.50

SINGLE FEMALES	5.98	9.43	5.17	3.60	3.64	6.33
MARRIED MALES	5.76	6.74	4.21	4.30	2.41	5.45
SINGLE MALES	5.07	5.77	2.04	3.02	1.45	4.61

TABLE III

	Absences of 5 days duration or less as percentage of total absences	Days lost in absences of 5 days duration or less as percentage of total days lost
Factory 1	82%	41%
Factory 2	88%	50%
Factory 3	85%	39%
Factory 4	81%	42%

TABLE IV

FACTORY 3 DURATION:

	M	T	W	T	F	TOTAL
1	417	266	280	172	487	1622
2	289	191	81	310	53	924
3	174	39	265	29	45	552
4	38	217	28	32	27	342
5	325	28	26	16	11	406
TOTAL ABSENCES BEGINNING ON DAY	1445	874	796	667	725	4507
DAYS LOST	4535	4811	4906	4861	5219	21822
MEAN DURATION	5.28	5.49	4.92	4.42	3.48	4.84

TABLE V

	Factory 2	Factory 3	Factory 4
Female	-0.26	-0.29	-0.16
Married	-0.24	-0.49	-0.34
Married Female	0.03	0.14	0.09

Table VI
DURATION RESULTS

VARIABLE	FACTORY 2 ESTIMATE (t-ratio)	FACTORY 2 ELASTICITY	FACTORY 3 ESTIMATE (t-ratio)	FACTORY 3 ELASTICITY	FACTORY 4 ESTIMATE (t-ratio)	FACTORY 4 ELASTICITY
CONSTANT	-2.799	1.513	-2.555	1.442	-2.103	1.479
	(-6.519)		(-7.398)		(-6.641)	
FEMALE	-0.421	0.134	0.345	-0.147	-0.591	0.282
	(-1.235)		(1.980)		(-2.571)	
MARRIED	-0.456	0.185	-0.450	0.147	-0.610	0.312
	(-1.964)		(-2.029)		(-2.840)	
FEM*MAR	0.404	-0.078	0.320	-0.089	0.213	-0.081
	(1.096)		(1.204)		(0.785)	
FULL TIME	-0.017	0.008	0.360	-0.121	0.087	-0.046
	(-0.067)		(2.681)		(0.577)	
ACCEPTABLE	-3.860	0.193	-0.690	0.031	-1.058	0.105
	(-7.635)		(-1.768)		(-3.747)	
NO SSP	-0.288	0.022	-1.286	0.072	-0.638	0.084
	(-0.765)		(-3.573)		(-2.591)	
DIST A/B	0.927	-0.499	-0.757	0.425	0.210	-0.148
	(3.052)		(-3.280)		(0.871)	
DIST B/C	-0.720	0.386	-0.540	0.303	-0.427	0.299
	(-1.712)		(-1.173)		(-1.565)	
TUESDAY	0.656	-0.074	0.416	-0.042	0.634	-0.093
	(2.408)		(2.493)		(3.757)	
WEDNESDAY	1.063	-0.088	0.559	-0.054	1.042	-0.101
	(3.222)		(3.441)		(5.164)	
THURSDAY	1.020	-0.082	0.169	-0.015	1.077	-0.091
	(2.565)		(1.001)		(4.668)	
FRIDAY	0.400	-0.025	-0.273	0.022	0.448	-0.030
	(1.510)		(-1.548)		(2.216)	
GRADE B 88	0.018	-0.000	-1.066	0.001	0.275	-0.000
	(0.100)		(-5.527)		(1.873)	
GRADE C 88	0.099	-0.000	-1.525	0.000	-0.069	0.000
	(0.280)		(-5.279)		(-0.355)	
$(\text{DIST A/B})^2$	-0.265		0.232		-0.026	
	(-2.884)		(4.013)		(-0.339)	
$(\text{DIST B/C})^2$	0.320		0.179		0.206	
	(2.154)		(1.082)		(2.175)	
ALPHA	1.850		1.772		1.422	
	(9.979)		(16.943)		(16.480)	
ln L	-366.865		-711.668		-705.108	
N	216		372		341	
Uncensored	73		118		101	
One end	114		213		184	
Both ends	29		41		56	

NOTE: Standard errors were computed from the analytic second derivatives of the log-likelihood. The estimated elasticities of expected duration were calculated at sample means of regressors, except distance to boundary which is entered in log form.